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ABSTRACT

The cost of providing adequate computer service is imposing an extraordinary strain on the budgets of many institutions of higher education, particularly small to medium sized institutions that do not have large, federally-funded research programs. They face 2 critical problems: (1) how to obtain sufficient computer services for student use so that a large percentage of their students can become familiar with the regularly used, modern, data processing techniques; and (2) how to provide adequate computer capability to hold and attract competent faculty members who wish to pursue research activities that require the use of large computing facilities. After careful analysis of the various modes available to small colleges, remote batch operations appear to provide the lowest cost alternative. It is convenient for administrative, student, and research uses, and is within the budgets of most small colleges. (HS)

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ECONOMICAL REMOTE TERMINALS FOR SMALL INSTITUTIONS

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Introduction

As a consequence of its impact on our civilization, the period from 1930 to 1970 can be called the age of the automobile. Many people believe the period from 1970 to 2000 will be the age of the computer. Already its application is important not only in its traditional area of physical sciences but also in the social sciences, law, business and even theology and medicine. It is not unreasonable to assert that "today anyone who is graduated from college without experience in the use of modern computers as applied in his profession has been seriously educationally cheated."

Many colleges and universities are pioneering in using modern computers in new and imaginative ways in the various disciplines. Such endeavors are meritorious and essential to progress, but many of the more exotic and spectacular uses are clearly beyond the budget capabilities of a small college.

The fundamental question facing such institutions is whether or not there is any possible way to provide a meaningful introduction to computer for a large fraction of the students at a cost that is not prohibitive. A positive answer to this question required a careful analysis of the basic requirements for a "meaningful exposure" and an imaginative and careful set of compromises between capabilities and cost. This project was directed toward heavy emphasis on cost analysis, operational characteristics, and cost reduction compromises to determine a system that would provide meaningful computer services to small and medium sized institutions at a price that they can afford.

Background of the Study

As pointed out in the President's Science Advisory Committee Report on Computers in Higher Education, the cost of providing adequate computer services is imposing an extraordinary strain on the budgets of many institutions of higher education. It is particularly acute for small to medium sized institutions that do not have large federally funded research programs. They face two critical problems: How to obtain sufficient computer services for student use so that a large percentage of their students can become familiar with the regularly used modern data processing techniques; and, how to provide adequate computer capability to hold and attract competent faculty members who wish to pursue research activities which require the use of large computing facilities.

This latter problem is particularly relevant to the Regional Research Program of the Office of Education, one of the major purposes of which is to encourage faculty members at small institutions to become interested and involved in educational research. Since many such projects will involve computer use, the question arises as to whether the institution could afford to provide such services to support the faculty member's interest after the grant expires. If not, he might well migrate to a larger institution where a computer is available.

Objectives

The major objective of this project as stated in the original proposal was to provide guidance for small to medium size colleges that want to implement computer services. The first step was to survey present computer usage in such institutions.

Typical Patterns of Use

To determine typical patterns of computer usage, extensive date from six institutions with student populations ranging from approximately one thousand to seven thousand students was carefully analyzed. The institutions selected were chosen to represent diversified types of institutions and a variety of uses. They include one medium size university, three small colleges, one junior college and one technical institute. There is no claim that they are completely representative; however, it seems logical to assume that the computer associated problems of these institutions are reflective of the population. The institutions surveyed in this study are shown in Table 1.

Table 1. Institutions Included in the Study.

Institution	Location	Fall--1971 Student Enrollment
Baylor University	Waco, Texas	6,536
Kings College	Wilkes Barre, Pa.	1,975
Ocala Jr. College	Ocala, Florida	1,454
St. Andrews	Laurinburg, N.C.	900
Texas State Tech.	Waco, Texas	4,000
Wilkes College	Wilkes Barre, Pa.	2,500

Regardless of the structural or disciplinic orientation of the institution, the computer usage can be quite clearly identified as instruction, research or administration. Usage priorities are determined by either administrators, faculty or both in the form of committees at each institution. An analysis of computer usage patterns in the areas of instruction, research and administration was done at the selected institutions discounting the manner by which usage is determined; yet recognizing that in some cases a

different priority setting procedure might have resulted in a very different distribution.

Instructional Usage Patterns

The number and percentage of students enrolled in data processing instruction during the fall semester of 1971 at the selected institutions is shown in Table 2. Column 2 of the table shows the percentage of students enrolled in data process instruction versus the total school student population.

Table 2. Student Enrollment in Data Processing Instruction

Institution	Students Enrolled in D.P.C.	Students Enrolled in D.P.C. vs Total
Baylor University	240	3%
Kings College	300	15%
Ocala Jr. College	70	4%
St. Andrews College	150	16%
Texas State Tech.	55	1%
Wilkes College	150	6%

Perhaps a more meaningful analysis of instructional usage patterns is that of actual student jobs rather than course enrollments. The average number of student jobs handled daily, weekly and monthly at the selected institutions is shown in Table 3. Data showing peak student jobs are also included in the table.

Table 3. Average Student Jobs

Institution	Average Student Jobs Hrly.	Wkly.	Mnthly.	Peak Student Jobs Hrly.	Dly.	Wkly.
Baylor University	22	174	870	32	191	955
Kings College	13	100	500	21	123	615
Ocala Jr. College	14	110	550	20	118	590
St. Andrews	37	300	1500	59	354	1770
Texas State Tech.	8	60	300	10	62	310
Wilkes College	13	100	500	19	113	565

The average number of hours of computer use for instructional purposes at the selected institutions is shown in Table 4.

Table 4. Average Number of Hourse of Computer Usage for Instructional Purposes

Institution	Average Number of Hours Dly.	Wkly.	Mnthly.
Baylor University	6	30	122
Kings College	5	25	101
Ocala Jr. College	1	5	25
St. Andrews	2	10	39
Texas State Tech.	6	30	116
Wilkes College	4	20	74

Research Usage Patterns

Small institutions have historically been dedicated to quality instruction and have conducted comparatively little research although there are indications that the amount is increasing. The data in Table 5 show the average number of hours of computer usage for research purposes on a daily, weekly and monthly basis.

Table 5. Average Number of Hours of Computer Usage for Research

Institution	Average Number of Hours Daily	Weekly	Monthly
Baylor University*	0	0	0
Kings College	0	0	0
Ocala Jr. College	0	0	0
St. Andrews	1	5	31
Texas State Tech.	2	10	38
Wilkes College	1/2	2	9

*Research is done on a large off campus machine.

Administrative Usage Patterns

The increased involvement in educational matters of federal and state governments has resulted in an increased usage of data processing to provide the multitude of varied reports required by these agencies. This is evident in the analysis of the selected institutions in this study. The average number of hours of computer usage for administrative purposes is shown in Table 6.

Table 6. Average Number of Hours of Computer Usage for Administrative Purposes

Institutions	Average Number of Hours Daily	Weekly	Monthly
Baylor University	9	45	187
Kings College	7	35	141
Ocala Jr. College	9	45	194
St. Andrews	8	40	183
Texas State Tech.	4	20	69
Wilkes College	5	25	101

A comparison of the total number of hours of computer use for instruction, research and administration is shown in Table 7.

Table 7. A Comparison of Computer Usage Shown by Percentage

Institutions	Instruction (Mnthly)	Research (Mnthly)	Administration (Mnthly)
Baylor University	39	0	61
Kings College	42	0	58
Ocala Jr. College	11	0	89
St. Andrews	16	12	72
Texas State Tech.	52	17	31
Wilkes College	41	4	55

Alternate Modes Available

Alcorn (1) described the variety of options relating to computer facilities which are available for small colleges. These include: (a) off-campus computers with no on-campus terminals; (b) terminals to off-campus computers; (c) cooperative use of computer; (d) mini to small on-campus computers; (e) cooperative use of computers with on-campus terminals; and (f) on-campus computer with communications capabilities.

It is clear from the usage patterns of the selected institutions that the service cannot be considered adequate unless it has the capabilities to handle instructional, administrative and research applications.

Alcorn also stressed that option (a) does not appear to be a reasonable alternative for small colleges and that "this type of service has uaually been thought of as temporary, or specialized at best." (2)

Most medium sized and many small institutions now have $2,500 to $3,500 per month computer installations for administrative purposes and many are attempting to provide some student and faculty use on these machines. However, this arrangement is usally far from satisfactory. The low ratio of student use in the institutions studied is primarily a result of the machine limitation and not a conscious education decision on the part of the institution. Such machines can accommodate only one job at a time and are usually shceduled for administrative applications at certain periods of the day and student use at others. They are often quite slow and inefficient in handling student-problems written in a variety of high-level languages; such as COBAL PL-1, FORTRAN IV. The very limited core memory makes most of these installations not only virtually useless for many research applications, but it

also generates high programming costs in virtually all application areas. In administrative applications, efforts to break complex applications into components that will fit within a small memory very greatly increases the costs of developing the programs. This last feature is insidious in that this hidden cost is not apparent to the administraters that approve the acquisition decisions, but it provides a very real cash outlay when the insitution starts using the machine.

One method of providing a very attractive service to the students is the use of time sharing. In this technique there are a number of students each with his own teletype connected to a common computer. This computer serves one terminal for a fraction of a second and then another for a fraction of a second, then another, and another, etc. The computers are generally fast enough that each student has the impression that he has the entire capacity of the computer at his disposal. This mode is often called "the conversational mode: in that the students type in a line of information and the computer immediately responds by printing out a result and waits for another message. Thus there is a continuous interchange between the student and the computer. A special language called BASIC that is particularly suited for such interactive use was developed at Dartmouth and is now in general use on such systems.

Such time-sharing systems can take one of two forms: either a large multi-instructional time sharing network with several institutions and perhaps several hundred terminals connected to one very large computer, or, the opposite extreme, where a very small computer (now called mini computers)

has from five to sixteen terminals in one classroom. The first option is attractive in that it provides all of the advantages that the very large machines possess, very large memories, very high speed, wide variety of subroutines etc; however, it is economically feasible only if the users are located within the same local rate telephone exchange. If the user must pay long distance phone charges, the cost becomes prohibitively expensive since a average student problem will generally tie up a line for 20 to 30 minutes.

The mini computer time sharing system is also very attractive for student use, but it has two major disadvantages in so far as small institutions are concerned: (1) it isn't cheap and (2) it is not practical for administrative applications. The purchase price of a system with eight terminals is about $56,000 with a maintance cost of approximately $620 a month additional. These costs must then be added to the costs of supporting a separate system for administrative use. Another disadvantage of the mini computer time-sharing system is the very narrow experience the student gets. Conversational BASIC is an excellent language for problem-solving exercises in many courses; however, it is also very desirable to give the student experience in the high-level languages such as COBAL, PL-1, FORTRAN IV, and the extensive file manipulation and information retrieval systems that he is most likely to encounter after graduation.

Suggested Systems

In the past year and a half Western Institute for Science and Technology has been studying computer usage patterns to devise a much lower

cost network that would retain the advantages of a large central computer and yet be economically feasible for small colleges.

Priority was given to student uses; however, it was recognized that a small institution cannot afford two specialized systems. Therefore, any recommended system must be applicable to all three major uses: administration, student and research. The cost of providing service to students then includes only the incremental communication costs that are in excess of the administrative requirements rather than a separate hardware system.

Such a cost re-education effort must carefully consider a wide variety of possible performance versus cost trade-offs to establish accurate estimates of what certain desirable features actually cost. Only then can a reasonable judgment be made as to whether they are worth it.

The following minimum requirements were felt to be essential for satisfactory large scale student use:

(A) Input preparation should be as convenient as possible, preferably involving only pencil and paper, so that there would be no need to schedule or queue up for access to hardware;

(B) The turnaround time, including queueing to use the terminal, should not exceed a few minutes;

(C) The incremental cost per participating student should be less than $10 per semester, so that it can be covered by a standard laboratory fee; and

(D) There should be a wide variety of high-level languages including at least COBOL, FORTRAN, PL-1, and extensive file manipulation capabilities.

The requirement for a variety of high-level languages available at all times, the desirability of being able to manipulate large files and the

need for a very large core memory for research applications all argue for the use of a very large computer to serve many small institutions. Richard V. deGrasse (3) in an intensive and excellently done study of remote computing did an exhaustive analysis of the economics involved in network systems. He concluded that "networks in higher education seem to be economically feasible and even preferred for the potential they hold for attaining economies of scale." However, as previously mentioned, communication charges are such a large component of time-sharing network costs that they seriously limit the geographical area that can be economically served. For this reason particular emphasis was placed on reducing line charges. This analysis led to a very interesting study of the trade off between phone line charges and terminal complexity. Recent developments in integrated circuits and other related hardware techniques have drastically reduced the cost of logic components and small memories to a level such that it is economically feasible to incorporate a mini computer with a few thousand characters of memory into each of the remote terminals.

After careful analyses of the various modes available to small colleges, remote batch operation utilizing such an "intelligent" terminal appears to provide the lowest cost alternative. In this system each institution has a terminal that consists of a small mini computer with a moderately high-speed card reader, a moderately high-speed line printer and a communications modem connected to a regular dial-up phone line. The card reader reads cards by reflected light so that it will read either a hole or a black mark interchangeably; thus, for administrative use, the cards can be key punched in the traditional manner. For student use a very simple

card marking guide has been devised that enables the students to mark their card with pencil or pen at home, in dorm rooms, in the classrooms, or anywhere that happens to be convenient. When the card deck has been prepared, the user places it in the card reader and dials-up the central computer. The central computer then signals the terminal that it is ready, the terminal then reads in the cards and transmits the information over the phone line to the central computer in one short high-speed burst. When the input deck has been read the terminal hangs up. As soon as the central computer has run the program, it will dial the terminal back and transmit the output to the printer in another short high-speed burst and hang up.

An analysis of the student use at these surveyed colleges indicated the average student FORTRAN program had 36 cards and required a transmission of 700 characters to the computer and 2900 characters back, for a total of 3600 characters. At a transmission rate of 200 characters per second this would require a total of 18 seconds of phone line usage for the entire program.

With a modest amount of additional memory, the mini computer in this terminal could also serve as a small self-standing computer which would be quite adequate for running small student programs or it could be used as the computer in a small time-shared system such as that described earlier. The speed of the computer is such that it could be handling remote batch operation and local time-sharing simultaneously if desired.

The question facing the college administrator is "Which end should one start?" Should one install a small time-sharing system with the expectation of later expanding it by the addition of the card reader, printer and

communication capability to make it into a remote batch terminal? Or, is it more logical to start with a remote batch terminal and then add the additional capabilities? The major factor in the decision would appear to be the requirement for administrative use. If there is administrative use it appears far more desirable to start with a remote batch terminal and then add the additional capabilities if and when the student load builds up to the point that the central computer and communication charges are greater than the incremental cost associated with expanding the terminal. Approximate costs of these options are indicated in the table below.

	Purchase Price	Main.Mnthly.
Remote batch terminal	21,500	$180
Additional memory for local batch BASIC	+ 5,000	+ 40
Additional cost for 8 teletype time-sharing	+45,000	+.500
Total	$71,500	$720

In either remote batch or the local batch mode one terminal can handle approximately 100 student programs per hour. In the time-sharing mode each teletype could handle two to four student problems per hour.

Summary

After careful analysis of the various modes available to small colleges, remote batch operations appear to provide the lowest cost alternative. It is convenient for all three uses (administrative, student and research) and is within the budgets of most small colleges. It can be expanded to include interactive time-shared when desired.

Perhaps the most significant conclusion of this study is that a short, high burst technique reduces line usage to the point that it appears quite feasible to use a nationwide WATS system. The area served by a computer center is thus no longer limited to a small region, but could actually include the entire continenatl United States.

In 1971, The Western Institute for Science and Technology proposed to the United States Office of Education that it support a nationwide education computer network aimed toward small colleges. The proposal was funded and the National Education Computer Service is to be in operation in the late fall of 1972, providing remote batch services to small colleges anywhere in the 48 contiguous states. The projected costs to the user institutions are:

Terminal lease and maintenance	$880/mo.
Administrative applications	35¢/student/mo.
Student and Instructional use	35¢/student/mo.